REMARKS

In the Office Action of November 14, 2002, Claims 1 - 11 were rejected. No claim was allowed. In response, Claims 1 - 11 are canceled without prejudice or disclaimer and new Claims 12 - 18 are added to the application. Reexamination and reconsideration are respectfully requested in view of the foregoing amendments and the following remarks.

The Invention

The present invention is directed to a plasma processing apparatus having a shape of a chamber for generating the plasma through inductive coupling. In particular, the invention as defined in new Claims 12 - 18 relates to a plasma processing apparatus comprising a vacuum chamber enclosing a portion where the plasma is generated and having a flat upper face and an inclined side wall around the portion such that the vacuum chamber has a trapezoidal form in a cross section, an antenna coil wound around the side wall, and a Faraday shield disposed between this coil and the inclined side wall and connected while being spaced apart from or in a floating position to a ground. This configuration, particularly, the feature that the vacuum chamber has a flat upper face and an inclined side wall around the portion such that the vacuum chamber has a trapezoidal form in a cross section, facilitates the formation of a flow of plasma toward a discharge unit below the chamber along the side wall surface inside the chamber.

Further, in accordance with the feature comprising an antenna coil wound around the side wall having an inclined shape of the vacuum chamber and a Faraday shield disposed between the coil and the inclined side wall and connected

while being spaced apart from a ground, it is possible to attain the effects and action described in the specification that a predetermined quantity of striking particles from plasma in the chamber toward the Faraday shield is generated and the amount of foreign materials or reaction products generated through interaction between the side wall surface of the chamber and plasma particles flowing toward a wafer is reduced, with the result that superior processing can be realized.

The new Claims 12 - 18 are supported, for example by Figures 17 - 20 and in the specification on pages 27 - 29. Accordingly, it is respectfully submitted that the new Claims 12 - 18 do not constitute new matter

Objection to the Specification

The Examiner objected to the specification because of an informality on page 3, lines 4 - 5. In response, the specification is amended to make the change the term "ratio" to "rate" in line 5. Accordingly, it is respectfully submitted that this objection is thereby overcome.

The Examiner objected to the Abstract on the alleged grounds that it does not reflect the subject matter of the claimed embodiment. In response, a new abstract is provided.

Objection to the Drawings

The drawings were objected to under 37 CFR 1.83(a). The Examiner alleges that the drawings fail to show a plate made of a conductor or semiconductor placed on an inner side of the upper face of the vacuum chamber wherein the plate is coupled to an RF, DC or ground.

In response, Figure 20 is amended to schematically show the plate coupled to an RF, DC or ground. This feature is described in detail in the specification, for example from page 28, line 21 to page 29, line 3. Accordingly, it is respectfully submitted that no new matter is introduced by the amendment

The above-described drawing correction is effected by a separate Letter to the Official Draftsman submitted herewith. Accordingly, it is respectfully submitted that the objection to the drawings is overcome.

Rejection of Claims 1 - 2, 4 - 7 and 9 - 11 under 35 U.S.C. §102(b) over Collins

Claims 1 - 2, 4 - 7 and 9 - 11 were rejected under 35 U.S.C. §102(b) as anticipated by Collins et al (U.S. Patent No. 5,556,501). The Examiner alleges that Collins et al teach a plasma processing apparatus comprising a coil antenna for generating a plasma, a radio-frequency power source and matching network for supplying radio-frequency electric power to the antenna, a vacuum chamber upper plasma generating portion, a Faraday shield comprising surfaces disposed around the walls of the cylindrical source in order to ensure plasma uniformity by reducing capacitive coupling, a gas supply unit connected to a gas distribution ring for supplying a gas into the chamber, a wafer support for supporting a wafer, and an AC power supply for applying a bias RF frequency to the wafer support, wherein, the upper section is defined by a dome comprising a cylindrical wall covered by a top at the upper face and supported on a processing chamber top wall at its lower face (the upper face has a smaller area than that of a lower face and the upper face is flat) and wherein the apparatus further includes a third electrode disposed in the upper section, the third electrode may be floating, grounded or connected to an RF

power source and the third electrode may have various configuration and can be made of various material such as aluminum or silicon. Further, regarding claims 5, 10, and 11 the Examiner alleges that Collins discloses a vacuum chamber including an upper plasma generating portion and a lower plasma processing section wherein the plasma generation section has a smaller width than the lower plasma processing section.

This rejection is respectfully traversed as it may be applied to new Claims 12 - 18 submitted herein. In particular, Collins does not teach or suggest any device wherein a vacuum chamber enclosing a portion where plasma is generated has a flat upper face and an inclined side wall around the portion such that the vacuum chamber has a trapezoidal form in a cross section. Moreover, although Collins discloses a Faraday shield, its Faraday shield is grounded. Collins does not teach or suggest a device wherein the Faraday shield is in a floating position to a ground.

Accordingly, it is respectfully submitted that the Claims 12 - 18 are not anticipated by Collins.

Rejection of Claim 3 and 8 under 35 U.S.C. §103(a) over Collins in view of Gorin

Claims 3 and 8 were rejected under 35 USC 103(a) as obvious over Collins in view of Gorin (U.S. Patent No. 4,464,223). The Office Action alleges that Collins teaches all limitations of the claims except for a DC voltage source coupled to the conductive plate (third electrode). The Examiner further alleges that Gorin teaches a plasma processing apparatus wherein an electrode may be coupled to an RF power source, to a DC power source, or being grounded through a series circuit and that

use of the DC power supply allows the amount of DC biasing induced by the plasma to be changed independently of pressure or power. The Examiner takes the position that it would have been obvious to one of ordinary skill in the art at the time of the invention to implement the bias power mechanism including the DC power source as taught by Gorin in the apparatus of Collins in order to control the amount of bias independently of pressure or power.

This rejection is respectfully traversed as it may be applied to new Claims 12 - 18 submitted herein. As discussed above, Collins does not teach or suggest any device wherein a vacuum chamber enclosing a portion where plasma is generated has a flat upper face and an inclined side wall around the portion such that the vacuum chamber has a trapezoidal form in a cross section and does not teach or suggest a device wherein the Faraday shield is in a floating position to a ground. Further, these features are neither taught nor suggested by Gorin.

Accordingly, it is respectfully submitted that Claims 12 - 18 would not have been obvious over Collins and Gorin, alone or in combination.

Rejection of Claim 1 - 2, 4 - 7 and 9 - 11 under 35 U.S.C. §103(a) over Li in view of Collins

Claims 1 - 2, 4 - 7 and 9 - 11 were rejected under 35 USC 103(a) as obvious over Li et al (U.S. Patent No. 5,772,771) in view of Collins. The Office Action alleges that Li teaches a plasma processing apparatus comprising a coil antenna for generating a plasma, a radio-frequency power source for supplying radio-frequency electric power to the antenna, a gas supply unit connected to a gas distribution nozzle for supplying a gas into the chamber, a substrate support for supporting a

substrate, and a bias radio-frequency power source for applying a bias RF frequency to the wafer support, wherein the housing includes a dome surrounded by the coils and having its upper face covered by a top and its bottom face sitting on a processing chamber side wall, and wherein the apparatus further includes a top acting an anode and is electrically biased by a second RF power source. The Examiner acknowledges that Li fails to teach a Faraday shield provided around the plasma generating portion. The Examiner alleges that Collins teaches a plasma processing apparatus including a Faraday shield in order to produce a plasma mainly inductively rather than capacitively. The Examiner takes the position that it would have been obvious to one of ordinary skill in the art at the time of the invention to employ the Faraday shield as taught by Collins in the apparatus of Li in order to generate a plasma mainly inductively. The Examiner further alleges that Collins teaches a plasma processing apparatus including a third electrode disposed in the upper section, that the third electrode may be floating, grounded or connected to an RF power source and the third electrode may have various configuration and can be made of various material such as aluminum (conductor) or silicon. The Examiner takes the position that it would have been obvious to one of ordinary skill in the art at the time of the invention to implement the bias mechanism including the grounding as taught by Collins in the apparatus of Li in order to enhance various processing characteristic including etch rate and plasma coupling. Further regarding claims 5, 10, 11, the Examiner refers to in re Gardner v. TEC Systems, Inc., 725 F.2d 1338, 220 USPQ 777 (Fed. Cir. 1984), cert. denied, 469 U.S. 830, 225 USPQ 232 (1984) wherein it was held that where the only difference between the prior art and the claims was a recitation of relative dimensions of the claimed device and a

device having the claimed relative dimensions would not perform differently than the prior art device, the claimed device was not patentably distinct from the prior art device.

This rejection is respectfully traversed as it may be applied to new Claims 12 - 18 submitted herein. In Li, the deposition chamber is described and depicted as having a dome shape. Accordingly, Li does not teach or suggest a chamber that has a flat upper face and an inclined side wall around the portion such that the vacuum chamber has a trapezoidal form in a cross section. Further, Li does not teach or suggest a Faraday shield, or, in particular, a Faraday shield that is in a floating position to a ground. As discussed above, these features are not taught or suggested by Collins.

Accordingly, it is respectfully submitted that Claims 12 - 18 would not have been obvious over Li and Collins, alone or in combination.

Rejection of Claim 3 and 8 under 35 U.S.C. §103(a) over Li in view of Collins and further in view of Gorin

Claims 3 and 8 were rejected under 35 USC 103(a) as obvious over Li in view of Collins and further in view of Gorin. The Office Action alleges that Li in combination with Collins teaches all limitations of the claims except for a DC voltage source is coupled to the conductive plate. The Examiner alleges that Gorin teaches a plasma processing apparatus wherein an electrode may be coupled to an RF power source, to a DC power source, or being grounded through a series circuit. The Examiner further alleges that use of the DC power supply allows the amount of DC biasing induced by the plasma to be changed independently of pressure or

power and that grounding will change the electrode area ratio between a high frequency electrode and a ground electrode is changed. The Examiner takes the position that it would have been obvious to implement the bias power mechanism including the DC power source as taught by Gorin in the apparatus of Collins in order to control the amount of bias independently of pressure or power.

This rejection is respectfully traversed as it may be applied to new Claims 12 - 18 submitted herein. As discussed above, Li does not teach or suggest a chamber that has a flat upper face and an inclined side wall around the portion such that the vacuum chamber has a trapezoidal form in a cross section. Further, Li does not teach or suggest a Faraday shield, or, in particular, a Faraday shield that is in a floating position to a ground. As discussed above, these features are not taught or suggested by Collins or Gorin.

Accordingly, it is respectfully submitted that Claims 12 - 18 would not have been obvious over Li, Collins and Gorin, alone or in combination.

Rejection of Claim 1 - 2, 4 - 7 and 9 - 11 under 35 U.S.C. §103(a) over Lu in view of Collins

Claims 1 - 2, 4 - 7 and 9 - 11 are rejected under 35 USC 103(a) as obvious over Lu et al (U.S. Patent No. 5,904,778) in view of Collins. The Office Action alleges that Lu et al teach a plasma processing apparatus comprising a coil antenna for generating a plasma; a radio-frequency power source for supplying radio-frequency electric power to the antenna; a plasma generating chamber defined by side wall and a top wall (vacuum chamber enclosing a plasma generating portion); a gas supply unit; a pedestal electrode (sample stage) for supporting a wafer; and a

bias radio-frequency power source 84 for applying a bias RE frequency to the wafer support wherein, the housing comprising a truncated conical dome having an RE inductive coil wrapped around its outside, and a roof (an upper flat and circular face), and a bottom side sitting on a processing chamber (the upper face has a smaller area than that of a lower face and the upper face is flat); and wherein the top wall 80 is grounded (a plate made of a conductor or semiconductor is placed on an inner side of the upper face of the vacuum chamber wherein the plate is grounded). The Examiner acknowledges that Lu fails to teach a Faraday shield provided around the plasma generating portion and a magnetic field generating device (means). The Examiner alleges that Collins teaches a plasma processing apparatus including a Faraday shield in order to produce a plasma mainly inductively rather than capacitively. The Examiner takes the position that it would have been obvious to employ the Faraday shield as taught by Collins in the apparatus of Lu in order to generate a plasma mainly inductively. The Examiner further alleges that Collins teaches a plasma processing apparatus including a third electrode disposed in the upper section, that the third electrode may be floating, grounded or connected to an RE power source, and that the third electrode may have various configuration and can be made of various material such as aluminum (conductor) or silicon (semiconductor) (a plate made of a conductor or semiconductor is placed on an inner side of the upper face of the vacuum chamber wherein an RE voltage is applied to the plate or the plate is grounded. The Examiner takes the position that it would have been obvious to implement the bias mechanism including the bias RE power source as taught by Collins in the apparatus of Lu in order to enhance various processing characteristic including etch rate and selectivity. Further regarding claims

5, 10, 11, the Examiner refers to in re Gardner v. TEC Systems, Inc., 725 F.2d 1338, 220 USPQ 777 (Fed. Cir. 1984), cert. denied, 469 U.S. 830, 225 USPQ 232 (1984) which holds that where the only difference between the prior art and the claims was a recitation of relative dimensions of the claimed device and a device having the claimed relative dimensions would not perform differently than the prior art device, the claimed device was not patentably distinct from the prior art device.

This rejection is respectfully traversed as it may be applied to new Claims 12 - 18 submitted herein. Lu does not teach or suggest a Faraday shield, or, in particular, a Faraday shield that is in a floating position to a ground. As discussed above, Collins does not teach or suggest a Faraday shield that is spaced apart from ground.

Accordingly, it is respectfully submitted that Claims 12 - 18 would not have been obvious over Lu and Collins, alone or in combination.

Rejection of Claim 3 and 8 under 35 U.S.C. §103(a) over Lu in view of Collins and further in view of Gorin

Claims 3 and 8 are rejected under 35 USC 103(a) as obvious over Lu in view of Collins and further in view of Gorin. The Office Action alleges that Lu and Collins teach all limitations of the claims as discussed above except for a DC voltage source is coupled to the conductive plated. The Examiner alleges that Gorin teaches a plasma processing apparatus wherein an electrode may be coupled to an RF power source, to a DC power source, or being grounded through a series circuit 44. The Examiner alleges that use of the DC power supply allows the amount of DC biasing induced by the plasma to be changed independently of pressure or power and that grounding will change the electrode area ratio between a high frequency electrode

(plasma source) and a ground electrode (return path) is changed. The Examiner takes the position that it would have been obvious to implement the bias power mechanism including the DC power source as taught by Gorin et al in the apparatus of Collins et al in order to control the amount of bias independently of pressure or power.

This rejection is respectfully traversed as it may be applied to new Claims 12 - 18 submitted herein. As discussed above, Lu and Gorin do not teach or suggest a Faraday shield, or, in particular, a Faraday shield that is in a floating position to a ground. As discussed above, Collins does not teach or suggest a Faraday shield that is spaced apart from ground.

Accordingly, it is respectfully submitted that Claims 12 - 18 would not have been obvious over Lu, Collins and Gorin, alone or in combination.

Conclusion

In view of the foregoing amendments and remarks, it is respectfully submitted that Claims 12 - 18 are in condition for allowance. Favorable reconsideration is respectfully requested.

Should the Examiner believe that anything further is necessary to place this application in condition for allowance, the Examiner is requested to contact applicants' undersigned attorney at the telephone number listed below.

Kindly charge any additional fees due, or credit overpayment of fees, to Deposit Account No. 01-2135 (520.35833VV5).

Respectfully submitted,
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Marked up copy to show changes made

IN THE SPECIFICATION

Please replace the paragraph beginning on page 2, line 8 with the following replacement paragraph:

The plasma density distribution is determined mainly by the generation rate distribution and by the state of transportation of ions and electrons. In the absence of an external magnetic field, the transportation of the plasma diffuses isotropically in every direction. At this time, electrons instantly escape and tend to reach the wall of the vacuum chamber because the mass is no more than 1/1,000 of that of an ion, but they are repelled by the sheath (ion sheath) formed in the vicinity of the wall. As a result, a quasi-neutral condition of the electron and ion densities is always met in the plasma, so that both the ions and electrons are bipolarly diffused toward the wall. At this time, the potential of the plasma takes on its maximum where the plasma density, i.e., the ion density, is the maximum. This potential is termed the plasma potential Vp, approximately expressed by $Vp \approx Te \times \ell n(mi/me)$, where Te, mi and me are the electron temperature, the mass of an ion, and the mass of an electron, respectively. In the plasma, the potential distribution is determined by the potential Vp and the wall potential (ordinally at 0 V), so that the density distribution is correspondingly determined. Since, in this case, the plasma is confined by the electrostatic field established by itself, the density distribution is determined by the shape of the apparatus, the place where the induced electric field takes on the maximum, and the ratio of the generation ~~ratio~~ rate/the bipolar diffusion flux.

ABSTRACT

A plasma processing apparatus includes a vacuum chamber enclosing a portion where plasma is generated and having an flat upper face and an inclined side wall around the portion such that the vacuum chamber has a trapezoidal form in cross-section, an antenna coil wound around the side wall, a power source for supplying a predetermined frequency electric power to the antenna coil, a Faraday shield disposed in a floating position to a ground and provided around the side wall enclosing the portion, a gas supply unit for supplying gas into the vacuum chamber, a sample stage on which a sample to be processed is placed, and a discharge unit for discharging the gas below the sample stage out of the vacuum chamber.